

Code of Federal Regulations

▼ Sec. K25.1

Part 25 AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES	
Appendix K	

Sec. K25.1

EXTENDED OPERATIONS (ETOPS)

This appendix specifies airworthiness requirements for the approval of an airplane-engine combination for extended operations (ETOPS). For two-engine airplanes, the applicant must comply with sections K25.1 and K25.2 of this appendix. For airplanes with more than two engines, the applicant must comply with sections K25.1 and K25.3 of this appendix.

K25.1 Design requirements.

K25.1.1 Part 25 compliance.

The airplane-engine combination must comply with the requirements of part 25 considering the maximum flight time and the longest diversion time for which the applicant seeks approval.

K25.1.2 Human factors.

An applicant must consider crew workload, operational implications, and the crew's and passengers' physiological needs during continued operation with failure effects for the longest diversion time for which it seeks approval.

K25.1.3 Airplane systems.

(a) Operation in icing conditions.

(1) The airplane must be certificated for operation in icing conditions in accordance with Sec. 25.1419.

(2) The airplane must be able to safely conduct an ETOPS diversion with the most critical ice accretion resulting from:

(i) Icing conditions encountered at an altitude that the airplane would have to fly following an engine failure or cabin decompression.

(ii) A 15-minute hold in the continuous maximum icing conditions specified in Appendix C of this part with a liquid water content factor of 1.0.

(iii) Ice accumulated during approach and landing in the icing conditions specified in Appendix C of this part.

(b) Electrical power supply. The airplane must be equipped with at least three independent sources of electrical power.

(c) Time limited systems. The applicant must define the system time capability of each ETOPS significant system that is time-limited.

K25.1.4 Propulsion systems.

(a) Fuel system design. Fuel necessary to complete an ETOPS flight (including a diversion for the longest time for which the applicant seeks approval) must be available to the operating engines at the pressure and fuel-flow required by Sec. 25.955 under any

airplane failure condition not shown to be extremely improbable.

Types of failures that must be considered include, but are not limited to: crossfeed valve failures, automatic fuel management system failures, and normal electrical power generation failures.

(1) If the engine has been certified for limited operation with negative engine-fuel-pump-inlet pressures, the following requirements apply:

(i) Airplane demonstration-testing must cover worst case cruise and diversion conditions involving:

(A) Fuel grade and temperature.

(B) Thrust or power variations.

(C) Turbulence and negative G.

(D) Fuel system components degraded within their approved maintenance limits.

(ii) Unusable-fuel quantity in the suction feed configuration must be determined in accordance with Sec. 25.959.

(2) For two-engine airplanes to be certificated for ETOPS beyond 180 minutes, one fuel boost pump in each main tank and at least one crossfeed valve, or other means for transferring fuel, must be powered by an independent electrical power source other than the three power sources required to comply with section K25.1.3(b) of this appendix. This requirement does not apply if the normal fuel boost pressure, crossfeed valve actuation, or fuel transfer capability is not provided by electrical power.

(3) An alert must be displayed to the flightcrew when the quantity of fuel available to the engines falls below the level required to fly to the destination. The alert must be given when there is enough fuel remaining to safely complete a diversion. This alert must account for abnormal fuel management or transfer between tanks, and possible loss of fuel. This paragraph does not apply to airplanes with a required flight engineer.

(b) APU design. If an APU is needed to comply with this appendix, the applicant must demonstrate that:

(1) The reliability of the APU is adequate to meet those requirements; and

(2) If it is necessary that the APU be able to start in flight, it is able to start at any altitude up to the maximum operating altitude of the airplane, or 45,000 feet, whichever is lower, and run for the remainder of any flight .

(c) Engine oil tank design. The engine oil tank filler cap must comply with Sec. 33.71(c)(4) of this chapter.

K25.1.5 Engine-condition monitoring.

Procedures for engine-condition monitoring must be specified and validated in accordance with Part 33, Appendix A, paragraph A33.3(c) of this chapter.

K25.1.6 Configuration, maintenance, and procedures.

The applicant must list any configuration, operating and maintenance requirements, hardware life limits, MMEL constraints, and ETOPS approval in a CMP document.

K25.1.7 Airplane flight manual.

The airplane flight manual must contain the following information applicable to the ETOPS type design approval:

(a) Special limitations, including any limitation associated with operation of the airplane up to the maximum diversion time being approved.

(b) Required markings or placards.

(c) The airborne equipment required for extended operations and flightcrew operating procedures for this equipment.

(d) The system time capability for the following:

(1) The most limiting fire suppression system for Class C cargo or baggage compartments.

(2) The most limiting ETOPS significant system other than fire suppression systems for Class C cargo or baggage compartments.

(e) This statement: "The type-design reliability and performance of this airplane-engine combination has been evaluated under 14 CFR 25.1535 and found suitable for (identify maximum approved diversion time) extended operations (ETOPS) when the configuration, maintenance, and procedures standard contained in (identify the CMP document) are met. The actual maximum approved diversion time for this airplane may be less based on its most

limiting system time capability. This finding does not constitute operational approval to conduct ETOPS." K25.2. Two-engine airplanes.

An applicant for ETOPS type design approval of a two-engine airplane must use one of the methods described in section K25.2.1, K25.2.2, or K25.2.3 of this appendix.

K25.2.1 Service experience method.

An applicant for ETOPS type design approval using the service experience method must comply with sections K25.2.1(a) and K25.2.1(b) of this appendix before conducting the assessments specified in sections K25.2.1(c) and K25.2.1(d) of this appendix, and the flight test specified in section K25.2.1(e) of this appendix.

(a) Service experience. The world fleet for the airplane-engine combination must accumulate a minimum of 250,000 engine-hours. The FAA may reduce this number of hours if the applicant identifies compensating factors that are acceptable to the FAA. The compensating factors may include experience on another airplane, but experience on the candidate airplane must make up a significant portion of the total service experience.

(b) In-flight shutdown (IFSD) rates. The demonstrated 12-month rolling average IFSD rate for the world fleet of the airplane-engine combination must be commensurate with the level of ETOPS approval being sought.

(1) For type design approval up to and including 120 minutes: An IFSD rate of 0.05 or less per 1,000 world-fleet engine-hours, unless otherwise approved by the FAA. Unless the IFSD rate is 0.02 or less per 1,000 world-fleet engine-hours, the applicant must provide a list of corrective actions in the CMP document specified in section K25.1.6 of this appendix, that, when taken, would result in an IFSD rate of 0.02 or less per 1,000 fleet engine-hours.

(2) For type design approval up to and including 180 minutes: An IFSD rate of 0.02 or less per 1,000 world-fleet engine-hours, unless otherwise approved by the FAA. If the airplane-engine combination does not meet this rate by compliance with an existing 120-minute CMP document, then new or additional CMP requirements that the applicant has demonstrated would achieve this IFSD rate must be added to the CMP document.

(3) For type design approval beyond 180 minutes: An IFSD rate of 0.01 or less per 1,000 fleet engine-hours unless otherwise approved by the FAA. If the airplane-engine combination does not meet this rate by compliance with an existing 120-minute or 180-minute CMP document, then new or additional CMP requirements that the applicant

has demonstrated would achieve this IFSD rate must be added to the CMP document.

(c) Propulsion system assessment. (1) The applicant must conduct a propulsion system assessment based on the following data collected from the world-fleet of the airplane-engine combination:

(i) A list of all IFSD's, unplanned ground engine shutdowns, and occurrences (both ground and in-flight) when an engine was not shut down, but engine control or the desired thrust or power level was not achieved, including engine flameouts. Planned IFSD's performed during flight training need not be included. For each item, the applicant must provide--

(A) Each airplane and engine make, model, and serial number;

(B) Engine configuration, and major alteration history;

(C) Engine position;

(D) Circumstances leading up to the engine shutdown or occurrence;

(E) Phase of flight or ground operation;

(F) Weather and other environmental conditions; and

(G) Cause of engine shutdown or occurrence.

(ii) A history of unscheduled engine removal rates since introduction into service (using 6- and 12-month rolling averages), with a summary of the major causes for the removals.

(iii) A list of all propulsion system events (whether or not caused by maintenance or flightcrew error), including dispatch delays, cancellations, aborted takeoffs, turnbacks, diversions, and flights that continue to destination after the event.

(iv) The total number of engine hours and cycles, the number of hours for the engine with the highest number of hours, the number of cycles for the engine with the highest number of cycles, and the distribution of hours and cycles.

(v) The mean time between failures (MTBF) of propulsion system components that affect reliability.

(vi) A history of the IFSD rates since introduction into service using a 12-month rolling average.

(2) The cause or potential cause of each item listed in K25.2.1(c)(1)(i) must have a corrective action or actions that are shown to be effective in preventing future occurrences. Each corrective action must be identified in the CMP document specified in section K25.1.6. A corrective action is not required:

(i) For an item where the manufacturer is unable to determine a cause or potential cause.

(ii) For an event where it is technically unfeasible to develop a corrective action.

(iii) If the world-fleet IFSD rate--

(A) Is at or below 0.02 per 1,000 world-fleet engine-hours for approval up to and including 180-minute ETOPS; or

(B) Is at or below 0.01 per 1,000 world-fleet engine-hours for approval greater than 180-minute ETOPS.

(d) Airplane systems assessment. The applicant must conduct an airplane systems assessment. The applicant must show that the airplane systems comply with Sec. 25.1309(b) using available in-service reliability data for ETOPS significant systems on the candidate airplane-engine combination. Each cause or potential cause of a relevant design, manufacturing, operational, and maintenance problem occurring in service must have a corrective action or

actions that are shown to be effective in preventing future occurrences. Each corrective

action must be identified in the CMP document specified in section K25.1.6 of this appendix. A corrective action is not required if the problem would not significantly impact the safety or reliability of the airplane system involved. A relevant problem is a problem with an ETOPS group 1 significant system that has or could result in, an IFSD or diversion. The applicant must include in this assessment relevant problems with similar or identical equipment installed on other types of airplanes to the extent such information is reasonably available.

(e) Airplane flight test. The applicant must conduct a flight test to validate the flightcrew's ability to safely conduct an ETOPS diversion with an inoperative engine and worst-case ETOPS Significant System failures and malfunctions that could occur in service. The flight test must validate the airplane's flying qualities and performance with the demonstrated failures and malfunctions.

K25.2.2 Early ETOPS method.

An applicant for ETOPS type design approval using the Early ETOPS method must comply with the following requirements:

(a) Assessment of relevant experience with airplanes previously certificated under part 25. The applicant must identify specific corrective actions taken on the candidate airplane to prevent relevant design, manufacturing, operational, and maintenance problems experienced on airplanes previously certificated under part 25 manufactured by the applicant. Specific corrective actions are not required if the nature of a problem is such that the problem would not significantly impact the safety or reliability of the airplane system involved. A relevant problem is a problem with an ETOPS group 1 significant system that has or could result in an IFSD or diversion. The applicant must include in this assessment relevant problems of supplier-provided ETOPS group 1 significant systems and similar or identical equipment used on airplanes built by other manufacturers to the extent such information is reasonably available.

(b) Propulsion system design. (1) The engine used in the applicant's airplane design must be approved as eligible for Early ETOPS in accordance with Sec. 33.201 of this chapter. (2) The applicant must design the propulsion system to preclude failures or malfunctions that could result in an IFSD. The applicant must show compliance with this requirement by analysis, test, in-service experience on other airplanes, or other means acceptable to the FAA.

If analysis is used, the applicant must show that the propulsion system design will minimize failures and malfunctions with the objective of achieving the following IFSD rates:

(i) An IFSD rate of 0.02 or less per 1,000 world-fleet engine-hours for type design approval up to and including 180 minutes.

(ii) An IFSD rate of 0.01 or less per 1,000 world-fleet engine-hours for type design approval beyond 180 minutes.

(c) Maintenance and operational procedures. The applicant must validate all maintenance and operational procedures for ETOPS significant systems. The applicant must identify, track, and resolve any problems found during the validation in accordance with the problem tracking and resolution system specified in section K25.2.2(h) of this appendix.

(d) Propulsion system validation test. (1) The installed engine configuration for which approval is being sought must comply with Sec. 33.201(c) of this chapter. The test engine must be configured with a complete airplane nacelle package, including engine-mounted

equipment, except for any configuration differences necessary to accommodate test stand interfaces with the engine nacelle package.

At the conclusion of the test, the propulsion system must be--

- (i) Visually inspected according to the applicant's on-wing inspection recommendations and limits; and
- (ii) Completely disassembled and the propulsion system hardware inspected to determine whether it meets the service limits specified in the Instructions for Continued Airworthiness submitted in compliance with Sec. 25.1529.

(2) The applicant must identify, track, and resolve each cause or potential cause of IFSD, loss of thrust control, or other power loss encountered during this inspection in accordance with the problem tracking and resolution system specified in section K25.2.2

(h) of this appendix.

(e) New technology testing. Technology new to the applicant, including substantially new manufacturing techniques, must be tested to substantiate its suitability for the airplane design.

(f) APU validation test. If an APU is needed to comply with this appendix, one APU of the type to be certified with the airplane must be tested for 3,000 equivalent airplane operational cycles.

Following completion of the test, the APU must be disassembled and inspected. The applicant must identify, track, and resolve each cause or potential cause of an inability to start or operate the APU in flight as intended in accordance with the problem tracking and resolution system specified in section K25.2.2(h) of this appendix.

(g) Airplane demonstration. For each airplane-engine combination to be approved for ETOPS, the applicant must flight test at least one airplane to demonstrate that the airplane, and its components and equipment are capable of functioning properly during ETOPS flights and diversions of the longest duration for which the applicant seeks approval. This flight testing may be performed in conjunction with, but may not substitute for the flight testing

required by Sec. 21.35(b)(2) of this chapter.

(1) The airplane demonstration flight test program must include:

- (i) Flights simulating actual ETOPS, including flight at normal cruise altitude, step climbs, and, if applicable, APU operation.
- (ii) Maximum duration flights with maximum duration diversions.
- (iii) Maximum duration engine-inoperative diversions distributed among the engines installed on the airplanes used for the airplane demonstration flight test program. At least two one-engine-inoperative diversions must be conducted at maximum continuous thrust or power using the same engine.
- (iv) Flights under non-normal conditions to demonstrate the flightcrew's ability to safely conduct an ETOPS diversion with worst-case ETOPS significant system failures or malfunctions that could occur in service.
- (v) Diversions to airports that represent airports of the types used for ETOPS diversions.
- (vi) Repeated exposure to humid and inclement weather on the ground followed by a long-duration flight at normal cruise altitude.

(2) The airplane demonstration flight test program must validate the adequacy of the airplane's flying qualities and performance, and the flightcrew's ability to safely conduct an ETOPS diversion under the conditions

specified in section K25.2.2(g)(1) of this appendix.

(3) During the airplane demonstration flight test program, each test airplane must be operated and maintained using the applicant's recommended operating and maintenance procedures.

(4) At the completion of the airplane demonstration flight test program, each ETOPS significant system must undergo an on-wing inspection or test in accordance with the tasks defined in the proposed Instructions for Continued Airworthiness to establish its condition for continued safe operation. Each engine must also undergo a gas path inspection. These inspections must be conducted in a manner to identify abnormal conditions that could result in an

IFSD or diversion. The applicant must identify, track and resolve any abnormal conditions in accordance with the problem tracking and resolution system specified in section K25.2.2(h) of this appendix. (h) Problem tracking and resolution system. (1) The applicant must establish and maintain a problem tracking and resolution system. The system must:

(i) Contain a process for prompt reporting to the responsible FAA aircraft certification office of each occurrence reportable under Sec. 21.4(a)(6) encountered during the phases of airplane and engine development used to assess Early ETOPS eligibility.

(ii) Contain a process for notifying the responsible FAA aircraft certification office of each proposed corrective action that the applicant determines necessary for each problem identified from the occurrences reported under section K25.2.2. (h)(1)(i) of this appendix. The timing of the notification must permit appropriate FAA review before taking the proposed corrective action.

(2) If the applicant is seeking ETOPS type design approval of a change to an airplane-engine combination previously approved for ETOPS, the problem tracking and resolution system need only address those problems specified in the following table, provided the applicant obtains prior authorization from the FAA:

If the change does not require a new airplane type certificate and . . .	Then the Problem Tracking and Resolution Sys
(i) Requires a new engine type certificate	All problems applicable to the new engine inst mainder of the airplane, problems in changed
(ii) Does not require a new engine type certificate	Problems in changed systems only.

(i) Acceptance criteria. The type and frequency of failures and malfunctions on ETOPS significant systems that occur during the airplane flight test program and the airplane demonstration flight test program specified in section K25.2.2(g) of this appendix must be consistent with the type and frequency of failures and malfunctions that would be expected to occur on currently certificated airplanes approved for ETOPS.

K25.2.3. Combined service experience and Early ETOPS method.

An applicant for ETOPS type design approval using the combined service experience and Early ETOPS method must comply with the following requirements.

(a) A service experience requirement of not less than 15,000 engine-hours for the world fleet of the candidate airplane-engine combination.

(b) The Early ETOPS requirements of K25.2.2, except for the airplane demonstration specified in section K25.2.2(g) of this appendix; and

(c) The flight test requirement of section K25.2.1(e) of this appendix.

K25.3. Airplanes with more than two engines.

An applicant for ETOPS type design approval of an airplane with more than two engines must use one of the methods described in section K25.3.1, K25.3.2, or K25.3.3 of this appendix.

K25.3.1 Service experience method.

An applicant for ETOPS type design approval using the service experience method must comply with section K25.3.1(a) of this appendix before

conducting the airplane systems assessment specified in K25.3.1(b), and the flight test specified in section K25.3.1(c) of this appendix.

(a) Service experience. The world fleet for the airplane-engine combination must accumulate a minimum of 250,000 engine-hours. The FAA may reduce this number of hours if the applicant identifies compensating factors that are acceptable to the FAA. The compensating factors may include experience on another airplane, but experience on the candidate airplane must make up a significant portion of the total required service experience.

(b) Airplane systems assessment. The applicant must conduct an airplane systems assessment. The applicant must show that the airplane systems comply with the Sec. 25.1309(b) using available in-service reliability data for ETOPS significant systems on the candidate airplane-engine combination. Each cause or potential cause of a relevant design, manufacturing, operational or maintenance problem occurring in service must have a corrective action or actions that are shown to be effective in preventing future occurrences. Each corrective action must be identified in the CMP document specified in section K25.1.6 of this appendix. A corrective action is not required if the problem would not significantly impact the safety or reliability of the airplane system involved. A relevant problem is a problem with an ETOPS group 1 significant system that has or could result in an IFSD or diversion. The applicant must include in this assessment relevant problems with similar or identical equipment installed on other types of airplanes to the extent such information is reasonably available.

(c) Airplane flight test. The applicant must conduct a flight test to validate the flightcrew's ability to safely conduct an ETOPS diversion with an inoperative engine and worst-case ETOPS significant system failures and malfunctions that could occur in service. The flight test must validate the airplane's flying qualities and performance with the demonstrated failures and malfunctions.

K25.3.2 Early ETOPS method.

An applicant for ETOPS type design approval using the Early ETOPS method must comply with the following requirements:

(a) Maintenance and operational procedures. The applicant must validate all maintenance and operational procedures for ETOPS significant systems. The applicant must identify, track and resolve any problems found during the validation in accordance with the problem tracking and resolution system specified in section K25.3.2(e) of this appendix.

(b) New technology testing. Technology new to the applicant, including substantially new manufacturing techniques, must be tested to substantiate its suitability for the airplane design.

(c) APU validation test. If an APU is needed to comply with this appendix, one APU of the type to be certified with the airplane must be tested for 3,000 equivalent airplane operational cycles.

Following completion of the test, the APU must be disassembled and inspected. The applicant must identify, track, and resolve each cause or potential cause of an inability to start or operate the APU in flight as intended in accordance with the problem tracking and resolution system specified in section K25.3.2(e) of this appendix.

(d) Airplane demonstration. For each airplane-engine combination to be approved for ETOPS, the applicant must flight test at least one airplane to demonstrate that the airplane, and its components and equipment are capable of functioning properly during ETOPS flights and diversions of the longest duration for which the applicant seeks approval. This flight testing may be performed in conjunction with, but may not substitute for the flight testing required by Sec. 21.35(b)(2).

(1) The airplane demonstration flight test program must include:

(i) Flights simulating actual ETOPS including flight at normal cruise altitude, step climbs, and, if applicable, APU operation.

(ii) Maximum duration flights with maximum duration diversions.

(iii) Maximum duration engine-inoperative diversions distributed among the engines installed on the airplanes used for the airplane demonstration flight test program. At least two one engine-inoperative diversions must be conducted at maximum continuous thrust or power using the same engine.

(iv) Flights under non-normal conditions to validate the flightcrew's ability to safely conduct an ETOPS diversion with worst-case ETOPS significant system failures or malfunctions that could occur in service.

(v) Diversions to airports that represent airports of the types used for ETOPS diversions.

(vi) Repeated exposure to humid and inclement weather on the ground followed by a long duration flight at normal cruise altitude.

(2) The airplane demonstration flight test program must validate the adequacy of the airplane's flying qualities and performance, and the flightcrew's ability to safely conduct an ETOPS diversion under the conditions specified in section K25.3.2(d)(1) of this appendix.

(3) During the airplane demonstration flight test program, each test airplane must be operated and maintained using the applicant's recommended operating and maintenance procedures.

(4) At the completion of the airplane demonstration, each ETOPS significant system must undergo an on-wing inspection or test in accordance with the tasks defined in the proposed Instructions for Continued Airworthiness to establish its condition for continued safe operation. Each engine must also undergo a gas path inspection. These inspections must be conducted in a manner to identify abnormal conditions that could result in an IFSD or diversion. The applicant

must identify, track and resolve any abnormal conditions in accordance with the problem tracking and resolution system specified in section K25.3.2(e) of this appendix.

(e) Problem tracking and resolution system. (1) The applicant must establish and maintain a problem tracking and resolution system. The system must:

(i) Contain a process for prompt reporting to the responsible FAA aircraft certification

office of each occurrence reportable under Sec. 21.4(a)(6) encountered during the phases of airplane and engine development used to assess Early ETOPS eligibility.

(ii) Contain a process for notifying the responsible FAA aircraft certification office of each proposed corrective action that the applicant determines necessary for each problem identified from the occurrences reported under section K25.3.2(h)(1)(i) of this appendix. The timing of the notification must permit appropriate FAA review before taking the proposed corrective action.

(2) If the applicant is seeking ETOPS type design approval of a change to an airplane-engine combination previously approved for ETOPS, the problem tracking and resolution system need only address those problems specified in the following table, provided the applicant obtains prior authorization from the FAA:

If the change does not require a new airplane type certificate and . . .	Then the Problem Tracking and Resolution Sys
(i) Requires a new engine type certificate	All problems applicable to the new engine ins mainder of the airplane, problems in changed
(ii) Does not require a new engine type certificate	Problems in changed systems only.

(f) Acceptance criteria. The type and frequency of failures and malfunctions on ETOPS significant systems that occur during the airplane flight test program and the airplane demonstration flight test program specified in section K25.3.2(d) of this appendix must be consistent with the type and frequency of failures and malfunctions that would be expected to occur on currently certificated airplanes approved for ETOPS.

K25.3.3 Combined service experience and Early ETOPS method.

An applicant for ETOPS type design approval using the Early ETOPS method must comply with the following requirements:

(a) A service experience requirement of less than 15,000 engine-hours for the world fleet of the candidate airplane-engine combination;

(b) The Early ETOPS requirements of section K25.3.2 of this appendix, except for the airplane demonstration specified in section K25.3.2(d) of this appendix; and

(c) The flight test requirement of section K25.3.1(c) of this appendix.